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(71) Applicant: AEROMOVER SYSTEMS CORPORATION [US/US]; 2500 Bishop Circle, East, Dexter, MI 48130 (US).

(72) Inventor: BIDARE, Srinivas, Ramakrishnaiah; Apartment 213, 1537 Natalie, Ann Arbor, MI 48105 (US).

(74) Agents: OBERHOLTZER, Steven, L. et al.; Harness, Dickey & Pierce, P.O. Box 828, Bloomfield Hills, MI 48303 (US).

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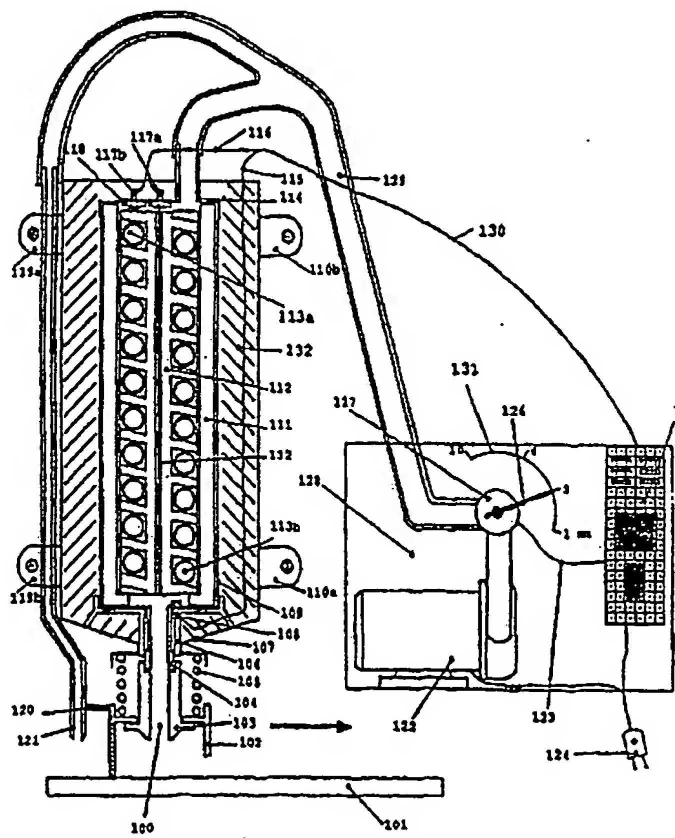
(54) Title: THERMAL JET GLASS CUTTER

(57) Abstract

An apparatus for thermal shock severing glass and similar materials in curved and odd shapes as well as linear cuts without ragged or serrated edges includes a thermal shock device (100) movable over and along a contour on the material to be cut (101). The device (100) has a helical passage with an inlet (114) connected to a pressurized source (122) of cold fluid and an outlet (104) communicating with a nozzle (103) through which the pressurized fluid heated to a high temperature by an electric heating element (113) in the passage is discharged onto the surface of the material (101). A cold fluid jet tube (121) connected to the cold fluid source (122) on the device (100) is arranged to direct a jet of cold fluid onto the contour preheated by the hot fluid from the nozzle (103) to cause the material (101) to fracture along the contour. A baffle (102) around the nozzle (103) confines the flow of hot fluid to the direction of travel of the device (100) and prohibits mixing of the hot fluid with the jet of cold fluid from tube (121). A control module (128) allows the volume of fluid and the hot fluid temperature to be adjusted in accordance with the thickness of the material (101).



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THERMAL JET GLASS CUTTER

FIELD OF THE INVENTION

This invention relates to the cutting of glass, using a cold fluid jet to produce a controlled thermal shock to induce a precisely propagated fracture of the glass. While not limited thereto in the capability, the present invention is an effective tool for severing glass and similar material in curved patterns and odd shapes as well as linear cuts without leaving serrated, or ragged edges.

BACKGROUND OF THE INVENTION

United States patent number 1,720,883, to F.N. Campbell, et al., discloses a method of severing glass along a defined line by applying heat to the zone of such line and other conditions in a manner whereby controlled expansion takes place and the glass is accurately severed at the desired line. The heat necessary for the invention is provided in a controlled method from a table and support system which separates the glass and pieces derived from the cutting process. The prior art is limited in its flexibility; that is, the pattern in which the glass is to be cut must be pre-determined and then the mechanism, or table must be reset each time a change in the cutting pattern is desired. The prior art utilizes bare copper wire laid within notches on the cutting table to provide heat for the cutting process, therefore, this method is

further inflexible because its mode of thermal transference must also be pre-patterned.

United States patent number 3,839,006, to Pikor, discloses an apparatus for cutting notch sensitive materials. The apparatus induces heat shock to notch sensitive materials, including glass. This apparatus includes a flexible resistance heater wire which may be applied to an article to be severed in overlying relationship to the desired fracture plane; the fracture plane usually being defined by a preconditioning step of scribing. The prior art is inflexible in its ability to transfer the necessary heat for the process because the mode of transference is a copper wire, patterns of severance are limited to shapes which can be overlayed by the wire. Pikor is also inflexible in that the glass must be scribed along the desired cut before the mode of heat transfer is applied to sever the glass.

United Kingdom patent number 1,357,116, to Pilkington Brothers Limited, discloses an invention which relates to the cutting of glass and in particular to the cutting of glass sheet material by inducing thermal stress within the glass. The apparatus provides a method of cutting glass sheet material which method comprises forming a point of weakness at a position on the glass, directing a stream of heated gas through a nozzle outlet towards the glass so that the stream is incident on the point of weakness to initiate a fracture in the glass, meanwhile restraining the flow of heated gas away from the area of glass adjacent the nozzle outlet by means of a restraining member symmetrically disposed around the nozzle outlet and extending perpendicular to the axis of the nozzle outlet, and effecting relative movement between the glass and the nozzle outlet along a path, the temperature and flow rate of the gas being controlled so that sufficient stress is generated in the glass to extend the fracture from the point of weakness along the path in a controlled fashion.

In summary, the prior art claims to generate a fracture by heating the glass by direct contact with a heated wire, heating of the glass by bringing the glass in close proximity to a heating wire, or, by heating the glass with a jet of hot gas. While heating the glass by any of the above methods will result in a fracture of the glass, precise control of the fracture line is difficult to achieve because the fracture actually occurs as the glass cools. Thus, the prior art relies on precision heating of the glass along the desired fracture line and depends upon ambient atmospheric air to cool the glass back to the line of fracture. At best, this is a random cooling process, particularly where the heating and cooling is not in a linear pattern. The prior art is limited, as cited in United Kingdom patent number 1,357,116, Pilkington Brothers Limited, in that small circles are impossible to cut in their entirety by the hot gas jet method of heating. The final few degrees cannot be cut by the hot gas method if the ambient atmospheric air is used for cooling, because the final few degrees will fracture uncontrollably in an undesirable fashion in a chord to the circle, therefore, use of mechanical means is required to complete the cut. This undesirable effect is caused by the retention of heat in the glass in the center of the circle which is subjected to constant application of heat; the retained heat cannot be dissipated quickly enough by ambient atmospheric air. However, if the exact track of the cooling gradient can be controlled, a precise, and controlled fracture can be achieved. The prior art attempts to control the fracture line by surrounding the hot air jet with a ring to control lateral dispersion of the hot air and consequently dissipation of heat through the glass. The exact line of the fracture is dependant upon the rate of cooling from the outside of the heated area to the center of the area which was heated. The present invention directs the cooling air to cause a fracture in any desired pattern and provides a

finished edge that requires no additional grinding, or cutting.

SUMMARY OF THE INVENTION

The present invention is a device to cut glass by thermal fracture with positive control of both the speed and direction of the fracture. Components of the device regulate both the overall temperature of the process as well as both the rate of heating and cooling of the material to be severed, the cooling portion being the most critical part of the process. The precise control of the line of fracture is generated by directing the cooling jet along the desired preheated line of fracture.

A preferred embodiment of the thermal jet glass cutter is comprised of a heating element that has been enclosed in a container made of a highly heat-resistant material. A pressurized fluid source provides ambient temperature fluid which is forced through the heating element causing said fluid to be heated. The heated fluid is then directed through a nozzle onto the glass surface. A sensor in the heating equipment regulates the temperature of said outgoing heated fluid. A hot fluid baffle partially encloses a small area around the nozzle to direct the flow of said hot fluid in the direction of travel, and prevents mixing of hot and cool fluid jets.

BRIEF DESCRIPTION OF THE DRAWING

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description, appended claims, and accompanying drawings where FIG. 1 is a sectional view of a preferred embodiment of the thermal jet glass cutter. FIG. 2 is a sectional view of another preferred embodiment wherein the cooling jet is positioned on the opposing plane of the glass, as may be desired when cutting thick material.

DETAILED DESCRIPTION OF THE DRAWING

The present invention is a thermal jet glass cutter having a thermal shock device and a control module. With reference to the drawings particularly FIG. 1, the instant invention has a control module 128 and a thermal shock device 100. The thermal shock device 100 is connected to the control module 128 by means of a fluid hose 129 and device control wires 130. The thermal shock device 100 moves along a contour on the material to be cut 101.

The control module 128 has a fluid pump 122 to provide fluid to the thermal shock device 100, and an electronic circuit board 125 that controls the temperature of a heating element 113 in the thermal shock device 100. A flow control valve 127 controls the fluid flow in the fluid hose 129. A selector knob 126 actuates the flow control valve 127 based on its position on a dial gauge 131. A feedback wire 123 serves as a control input from the selector knob 126 to the electronic circuit board 125. A power input cord 124 provides power to the heating element 113 and the fluid pump 122.

The thermal shock device 100 has a hot fluid baffle 102 to direct the flow of hot fluid in the direction of travel, and to prohibit mixing of the hot and cool fluid jets. The nozzle 103 is attached to an outlet tube 104. The outlet tube 104 is rigidly connected to an inner sleeve 109. In the preferred embodiment, the nozzle 103 is attached to the outlet tube 104 using screw threads for easy disengagement. The hot fluid baffle is also calibrated to measure clearance between the thermal shock device 100 and the material to be cut 101 using an indicator 120.

The heating element 113 is a continuous helix starting at 113a and ending at 113b. A heat-resistant helical inner core 112 supports the heating element 113. The helical inner core 112 is encased in a heat-resistant cylinder 111. The electrical circuit of the heating element 113

terminates at terminal posts 117a and 117b. The device control wires 130 containing a temperature sensor wire 115 and power wires 116, connects the thermal shock device 100 and the electronic circuit board 125. The sensor wire 115 is connected to a temperature sensor 108.

The inner sleeve 109 is supported by a spacer 106. The inner sleeve 109 is rigidly attached to an inlet tube 114. The spacer also insulates the outlet tube 104. The inner sleeve 109 is encased in a thermal shock device housing 107. The preferred embodiment of the thermal shock device housing 107 has mounting tabs 119 and 110. The space between the inner sleeve 109 and the thermal shock device housing 107 is filled by an insulating material 132. A heating core assembly 133 is comprised of the inner sleeve 109, the helical heating element 113, the helical inner core 112 and the heat-resistant cylinder 111. A tensioning spring 105 suspends the hot fluid baffle 102 from the thermal shock device housing 107 and maintains contact between the hot fluid baffle 102 and the material to be cut 101.

A cold fluid jet tube 121 is attached to the thermal shock device housing 107 using mounting tabs 119a and 119b. In the preferred embodiment, the inlet tube 114 and the cold fluid jet tube 121 are connected to the control module 128 by means of the fluid hose 129. The thermal shock device 100 can be conveniently attached to mounting devices and/or mechanisms using mounting tabs 119a, 119b, 110a and 110b.

The selector knob 126 is set by the operator according to the thickness of the material to be cut 101. The fluid pump 122 delivers the fluid which is regulated by the flow control valve 127. The fluid flows from said flow control valve 127 through the fluid hose 129 into the inlet tube 114. The fluid flows into the heat-resistant helical inner core 112 and flows concentricly through the heating element 113 to the outlet tube 104. As the fluid flows through the

heat-resistant helical inner core 112, it is heated to a high temperature. The fluid flows out through the nozzle 103 and strikes the material to be cut 101. The process of heating the material to be cut 101 prepares the material to be cut 101 for the cold fluid jet flowing from the cold fluid jet tube 121.

With reference to FIG. 2, the configuration places the hot fluid nozzle 202 above the glass 201 with the cold fluid nozzle 203 on the opposite pane of the glass 201. The remainder of the thermal shock device 101 remains the same as in FIG. 1. The direction of travel remains the same as indicated by the arrow in FIG. 1.

What is claimed is:

1. A portable thermal jet apparatus for cutting glass by inducing thermal shock along a desired line of fracture comprising:

a control module that regulates the temperature and flow rate of fluid flowing through the apparatus and the means to vary both;

a pressurized fluid source that supplies controlled fluid flow through an arrangement of conduit system for hot and cold fluid;

a continuous helical heating element supported by a heat-resistant helical core encased in a heat-resistant container;

a conduit system for a fluid flow path from the pressurized fluid source that passes through said heat-resistant container increasing the temperature of the fluid passing through the conduit system, terminating at a shaped hot discharge nozzle;

a conduit system that carries relatively cold fluid from the pressurized fluid source to a cold fluid discharge nozzle that is shaped to direct the fluid along the desired line of fracture;

a calibration guide to control the distance between the glass to be cut and the hot and cold fluid discharge nozzles, and;

a temperature sensor to regulate the hot fluid temperature.

2. The portable thermal jet apparatus for cutting glass of Claim 1 wherein a jet of hot fluid is directed at an initial point of weakness in the material and along a desired line of fracture to prepare the glass for an on coming jet of cooler fluid along the desired precise line of fracture.

3. The portable thermal jet apparatus for cutting glass of Claim 1 comprising a fluid heating chamber including:

said heat-resistant helical inner core that supports a heating element;

a spacer that insulates an outlet tube, and;

a housing that encases the fluid heating core assembly separated from said fluid heating core assembly by an insulating material.

4. The portable thermal jet apparatus for cutting glass of Claim 1 wherein said apparatus further comprises:

a hot fluid baffle located around said hot discharge nozzle and used to redirect hot fluid issuing from said hot discharge nozzle and prevent mixing of hot and cold fluids.

5. The portable thermal jet apparatus for cutting glass of Claim 1 wherein said apparatus further comprises:

a tensioning spring is used to maintain contact between the hot fluid baffle and the surface of the glass.

6. The portable thermal jet apparatus for cutting glass of Claim 1 comprising:

a thermal shock device;

a control module, and;

a fluid hose and device control wires which connect the thermal shock device to the control module.

7. A thermal jet apparatus for cutting glass by inducing thermal shock along a desired line of fracture, said apparatus comprising:

at least one pressurized fluid source that supplies a controlled fluid flow;

a thermal shock device including a heat source, a first conduit system and a second conduit system, said

first and second conduit systems being coupled to said fluid source, said first conduit system defining a fluid flow path from the pressurized fluid source being in relative proximity to said heat source such that the temperature of the fluid passing through said first conduit system is increased by said heat source, said first conduit system terminating in at least one hot fluid discharge nozzle, said second conduit system defining a fluid flow path from the pressurized fluid source being in relative proximity to said heat source such that the temperature of the fluid passing through said second conduit system is not increased by said heat source, said second conduit system terminating in at least one cold fluid discharge nozzle, said hot and cold discharge nozzles being arranged relative to one another in a predetermined relation such that a hot jet from said hot discharge nozzle impacts the glass and a cold jet from said discharge nozzle impacts the glass thereby causing the glass to fracture along a predetermined line; and

control means for regulating and varying the flow rate of fluid flowing through the apparatus and the temperature of the fluid being discharged through said hot discharge nozzle.

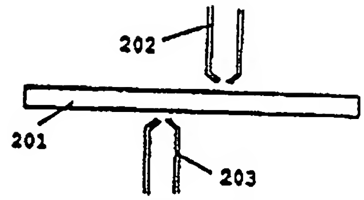

Figure-2

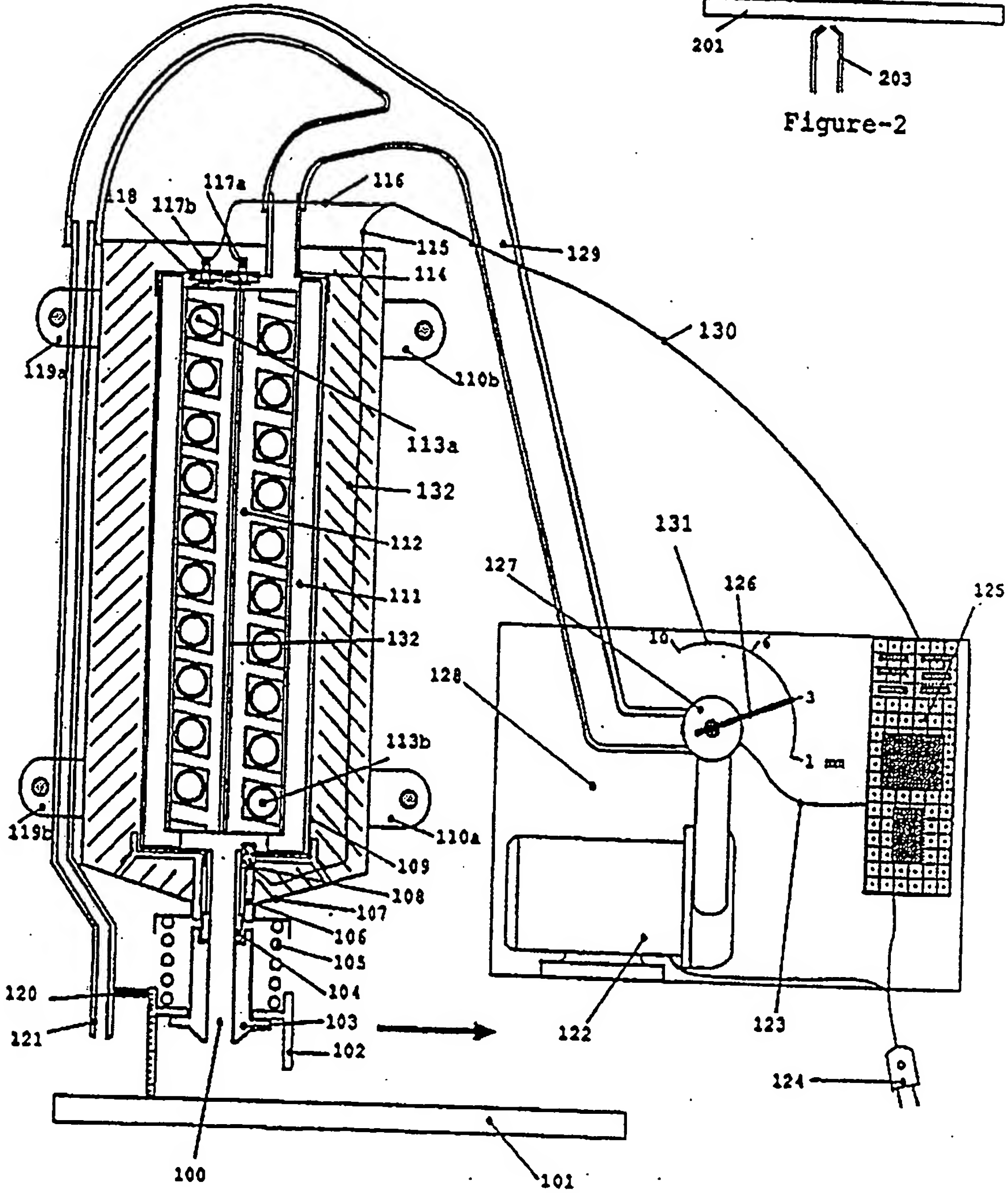

Figure 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/12522

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :Please See Extra Sheet.
US CL :225/93.5 ; 392/379 ,473; 156/497
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 225/93.5 ; 392/379 ,473; 156/497 ; 392/382-385 ,474-477

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,453,097 (Hafner) 01 July 1969.	1-7
A	US, A, 3,635,454 (Angelo et al) 18 January 1972.	1-7
A	US, A , 3,324,625 (Dulmage) 13 June 1967.	1-7
A	US, A, 3,422,247 (Royston et al) 14 January 1969.	1-7
A	JP, A, 02-41,771 (Nakagawa) 09 February 1990.	1-7
A	CH, A, 250,103 (Schilter et al) 16 March 1928.	1-7
A	US, A, 1,991,734 (Eaton) 19 February 1935.	1-7

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search
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Authorized officer
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Telephone No. (703) 308-1147

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INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER:
IPC (5):

C03B 33/09, 33/10 ; F24H 1/10 ; H05B 1/02